Concept-Focused Teaching

Using big ideas to guide instruction in science

By Joanne K. Olson

One of the main problems we face in science teaching is that students are learning isolated facts and missing central concepts. For instance, consider what you know about life cycles. Chances are that you remember something about butterflies and stages, such as egg, larva, pupa, adult. But what's the take-home idea that we should have learned about life cycles? Do students really need to know "egg, larva, pupa, adult?" Why butterflies? Why not some other organism? What do we need to know about the life cycle that is central to *all* organisms?

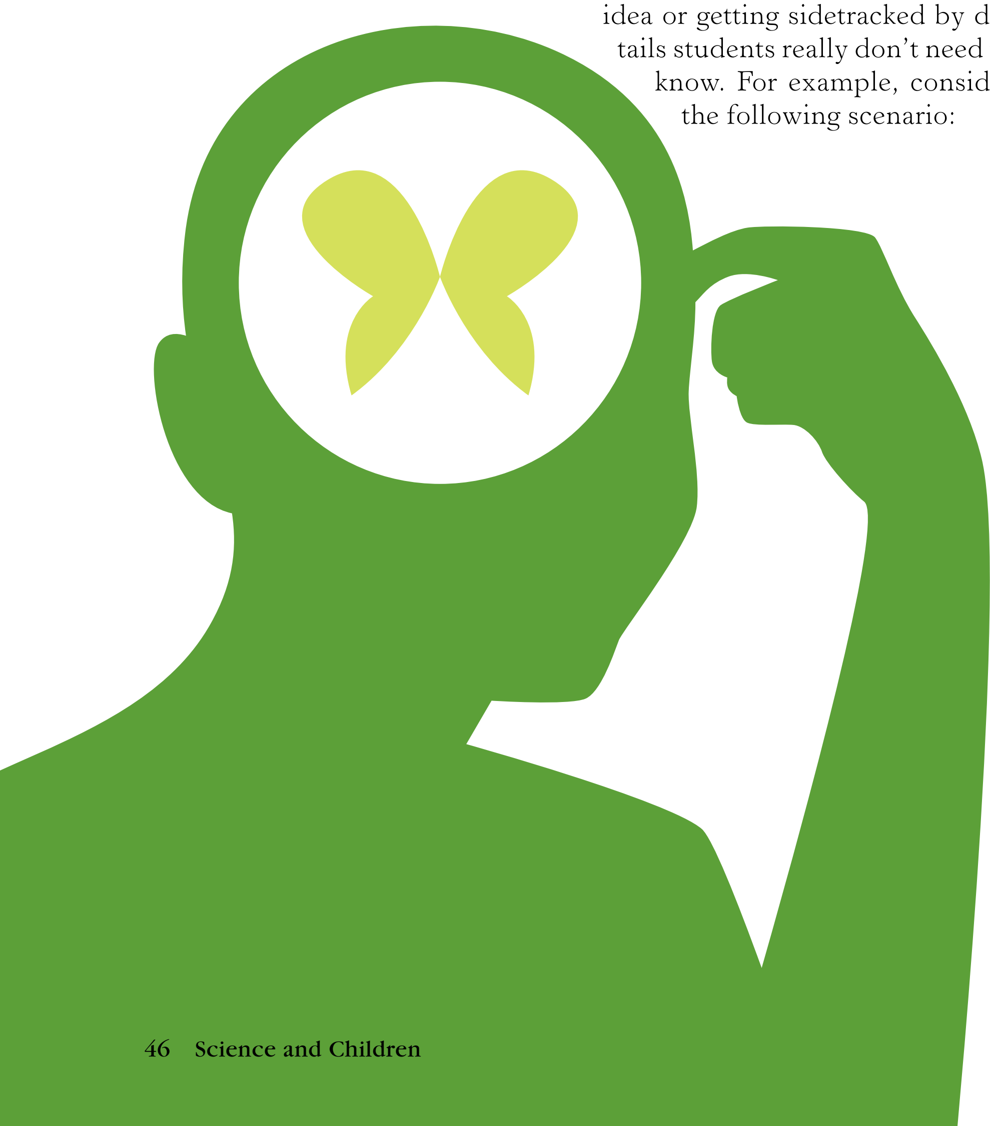
A crucial decision teachers must make is the "take-home message"—the big idea—that students should learn. This is the central concept that should last long after experiences and facts have faded from memory.

The fact is, "egg, larva, pupa, adult" is *not* the important idea. The central idea is that all living things (including plants) have a life cycle that consists of birth, growth, reproduction, and death. *Egg, larva, pupa,* and *adult* are simply the names given to stages of one organism's life cycle—the butterfly. Many of us learned these specific details and missed the main message, which is that life cycles are common across people, plants, hamsters, butterflies, worms, dogs, horses, and birds. So, our challenge as teachers is to make sure *our* students do not miss the messages. An important way to address this is to remain focused on the central concept—i.e., the big ideas—rather than topic-focused teaching.

Teaching to Big Ideas

Teaching to big ideas makes a lot of sense. Most students dislike science because teachers have too often taught disconnected facts and missed the big ideas (Tobias 1990). Traditional end-of-unit tests typically target how well students memorized facts, terms, and formulas. Such details are quickly forgotten. This is evident in numerous research studies that show that the public does not understand fundamental concepts of science (Chicago Museum of Science and Industry 2008; Shamos 1995). In fact, students can graduate from college with a science-related major and still not understand fundamental concepts (Schneps and Sadler 1997).

Unfortunately, many K–12 classrooms are filled with science time spent on details that students will either quickly forget or that they don't need to know. To remedy this situation, teachers have to be very clear about what big idea(s) students should know. Teachers have to know what the big idea is before they begin the unit and then carefully structure the instructional sequence to promote the learning of that central idea. They constantly have to revisit the big idea and question whether or not their teaching is targeting the big idea or getting sidetracked by details students really don't need to know. For example, consider the following scenario:



Jamie is a second-grade teacher. The learning standard she is supposed to address is: "Each plant or animal has different structures that serve different functions in growth, survival, and reproduction." Jamie decides to begin with plants and looks on the internet for plant-related lesson plans. She finds several great activities that involve growing plants in the classroom. She sets up a plant area on the windowsill and has students plant bean seeds and measure their growth. She uses worksheets she found in a popular teachers' magazine that has students identify and label the parts of the plant: seed, roots, stem, leaves, and flowers. Because she is interested in helping students see connections between disciplines, she finds several children's literature books on plants. Students are assessed on how well they can name the parts of the plant and order several pictures showing the growth of the plant. Following this, she plans a unit on animals.

Jamie's situation reflects a common planning practice among teachers: she searches for topic-related activities, and this directed her away from the big idea. At the end of the experience, what will the students have likely learned,

and how closely is it aligned with the standard?

In Jamie's classroom, students will likely have learned some facts about plants: the names of the parts of the plant and stages of plant growth. Yet, they will have missed the crucial concept that the functions of the plant are carried out by specific structures that serve those functions. They will likely miss the concept of plant function entirely and they will make little or no connection to the structure/function similarities during the subsequent animal unit. The children's literature is topic-related, but it also fails to help students gain a meaningful understanding of the big idea as identified in the standard.

When children are asked by parents what they are learning in science, children are likely to say, "We're learning about plants." This is one indication that instruction is topic-focused rather than concept-focused.

Moving to Concept Focused

In the above example, "growing a plant" is not an objective stated in the learning standard. This doesn't mean that a teacher shouldn't grow plants from seeds in the instructional sequence, but that if this experience is included, it should not be the focus of the instruction. The bean plant and its parts are *examples* that should be used to teach a larger concept—in this case that plants have different structures that serve different functions in growth, survival, and reproduction. To get students to understand that larger concept, the teacher can't focus on having them memorize plant parts or order stages of plant growth. Instead, the teacher needs to provide experiences *after* students have worked with the plant (activities, discussions, teacher-introduced information, etc.) to help students learn the important functions of a plant, and then focus them on how the structure of the plant enables those functions to occur.

For example, after watching several plants grow and produce seeds, Jamie could help students list or draw important plant structures on a chart, and then work to determine the functions that each structure serves. Students may notice that flowers precede seed development, and that the seeds are produced from the flower structure. Students will likely notice that roots help support the plant, and further investigations (e.g., cutting celery plants, or placing a wilted philodendron's roots in water) will demonstrate another important function of roots—to absorb water. Once students have completed their chart, Jamie could work with students to develop a single sentence "big idea" of the unit thus far: "We learned that ____." Student responses to this prompt will help Jamie know how much additional work needs to be done to move students toward the central concept that the structures of a plant have certain functions that help it grow, survive, and reproduce.

Jamie would then use this same approach—i.e., conduct lessons that focus on the relationship between structure and function in *animals*—during the subsequent unit on animals, again helping students move from experiences and observations to the connection between structure and function. Students can investigate animal feet, mouth parts, wings, eyes, legs, and other structures to determine how those structures help the organism grow, survive, or reproduce. This could coincide with a field trip to a local zoo or aquarium. The unit can culminate with students generating charts that list various functions of living things, both plants and animals, and specific examples of structures that enable a particular living thing to achieve those functions. A summary sentence

of the big idea could be developed by the class on large poster paper and remain in the room to be connected to other structure and function-related science concepts learned in the future (e.g., simple machines).

In this way, instruction is focused on the central concept and supported by examples, and students are more likely to respond to parents about their science experiences by saying, "We learned *that* the kind of structures living things have affects the functions they can do." This response is very different than, "We learned *about* plants."

Beyond Objectives

Teaching to the big idea requires that instructional experiences be carefully selected and sequenced so that students' understanding is built over time and results in a deep conceptual grasp of the standard. Unfortunately, several time-honored traditions exist in schools that actually work against teaching for conceptual understanding. Many of us were taught that each lesson should have a behavioral objective—a statement of what students are to do that shows that they have mastered that day's lesson. What is problematic about emphasizing daily behavioral objectives in science is that such objectives often require students to simply perform trivial skills or recall information after only a short period of instruction. Instead, students should be wrestling with the big idea over time and remain focused on that concept rather than getting tangled in the details. For example, when students are expected to "correctly label the parts of a plant" they may quickly succeed on this task yet not at all understand the fundamental concept in the standard.

Many teachers gravitate toward objectives, such as "Students will describe features of the rain forest, desert, and ocean and name three plants and three animals that live in each environment," and think that the Standards are vague. However, take a closer look at the objectives and what that might mean for how you teach science content. When teachers frame their instruction around this objective, you'll notice that the focus is on only three environments (desert, rain forest, ocean) and on only three plants and three animals in each. This objective is quite clear for the teacher. He or she could spend a day or a week on each environment, bringing in some activities or books and get the students to describe features and name three plants and animals fairly quickly. But is this worth knowing? The objective strays from the big idea, and students are assumed to understand science if they can do the simple task of naming plants and animals and matching them to the correct environment. Students may accomplish this task and know *nothing* of the fundamental science idea. Whenever we take a standard (in this case—The world has many different environments, and distinct environments support the life of different types of organisms) and change it into an objective, we run the very real risk of reducing the content to trivia. In this case, it could have been a meaningful unit focused on the diversity of environments in the world and how different environmental factors (rainfall, elevation, soil type, sunlight) support different organisms. Instead, it became, "Here are three environments. Name three animals and plants in each." Note the major difference in cognitive demand. Understanding the Standard requires that the student synthesize across multiple environments and look at what they have in common and how their differences result in different organisms that live there. With a focus on the objective,

students simply name organisms and match them to the correct environment.

Another problem with the objective is that it somewhat randomly picks three environments and wants students to name three plants and three animals. Why the rain forest? Why not prairies or the arctic tundra? When the focus is so narrow, certain environments are picked because of strange reasons—the teacher has children's literature on the topic or simply likes one environment over the other. Students get a small slice of a few environments and don't really see the big idea. And why are only three animals and three plants chosen? Again, the objective appears arbitrary, and students can succeed in doing this task and know nothing of the central idea that the world has many different environments and that distinct environments support the life of different types of organisms.

Learning Takes Time

Expecting students at the end of each lesson to "label, name, describe, solve, etc." may be acceptable for basic letter/sound recognition, multiplication facts, and other skills. However, concepts are much more complex to assess. Often, to tell if students really understand, teachers have to watch and listen to them over time and in a variety of contexts. We often cannot have a student complete a single behavior aligned to an objective and then draw the conclusion that a student understands a complex concept. Many days and even weeks of work are often required to get students focused on the central concept, including activities, discussions, collaborative work to make sense of data, teacher-introduced information, consolidation experiences, and application activities.

Focusing on standards necessitates that teachers make decisions about how to best help students reach that level of understanding. This means making important choices about what examples to use and how to help students see the examples as just that—examples—while focusing students' attention on the larger concept they are expected to learn. Doing so will alleviate the "trivial pursuit" found in so many science classrooms and will help students better see the forest through the trees.

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Connecting to the Standards

This article relates to the following *National Science Education Standards* (NRC 1996).

Teaching Standards

Standard A

- Teachers of science plan an inquiry-based science program for their students.

Standard D

- Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academy Press.

References

Chicago Museum of Science and Industry. 2008. *The state of science in America*. Harris Interactive: Chicago.

Schneps, M.H., and P. Sadler. 1997. *Minds of our own*. Boston: Harvard Center for Astrophysics.

Shamos, M.H. 1995. *The myth of scientific literacy*. New Brunswick, NJ: Rutgers University Press.

Tobias, S. 1990. *They're not dumb, they're different: Stalking the second tier*. Tucson, AZ: Research Corporation.